Finding niches in green innovation policy

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Technological innovation can potentially play a key role in today's environmental policy. However, the environmental innovations needed often are not market driven. Green innovation policy is needed to stimulate the development and implementation of sustainable innovations. The question is how green policy can systematically match needs across different innovations and sectors, so that operational efficiency and effectiveness are by design optimal. An important issue here is the alignment of green policy with other innovation related policies. Innovation is a process with many inter-linked activities in diverse sectors with implicit weak links. Often policy supports a single link and the innovation chain meets several bottlenecks in other weak links. An efficient and effective policy addresses as many barriers as possible so that the entire the chain of innovation is strengthened. This paper presents a model that enables a systematic approach to assess the degree of integration of national policies by looking at the match (or mismatch) of diverse policy instruments from different institutions in the Dutch policy context

1. Introduction

Technological innovation can potentially play a key role in today's environmental policy. However, the environmental innovations needed often are not market driven. Green innovation policy is needed to stimulate the development and implementation of sustainable innovations. The question is how green policy can systematically match needs across different innovations and sectors, so that operational efficiency and effectiveness are by design optimal. An important issue here is the alignment of green policy with other innovation related policies. Policy integration across different sectors and policy domains has been an ideal in the realm of policy making for decades (Cafruny and Rosenthal, 1999). It is only recently that integration has been acknowledged only as an 'ideal situation'. Given the very many different issues, stakeholders affected and capacities in diverse domains, recently is has been acknowledged that integration of sustainability policies is an unrealistic target (The Blueprint Network Report, 2004). Currently a more humble target has been set as a prerequisite for a coherent functioning of diverse policy agencies, that of coordination (Hogl, 2002).

One of the main arguments of this paper, aiming at coordination of innovation policies, is that innovation is a process with many inter-linked activities in diverse sectors with implicit weak links. Often specific policies support single links and the innovation chain meets several bottlenecks in other weak links. An efficient and effective policy coordination should aim to address as many barriers as possible so that the entire the chain is strengthened.

This paper presents a method for policy analysis that enables a systematic approach to assess the degree of integration of national policies by looking at the match (or mismatch) of diverse policy instruments from different institutions. The method takes into account five innovation policy dimensions: First we look at the *type of innovation* promoted. This is done from the perspective of sustainable innovation differentiating between system innovations, industrial ecology, singular innovations, end-off-pipe technologies and process/product adjustments. Second we explore the current state and future of the *innovation trajectory*. A comparison is made along the life cycle of the innovations promoted. Third we determine the *generic barriers* that an innovation must overcome in order to diffuse, looking at economic, institutional, organizational and technological barriers. Fourth, the *technological characteristics* at the micro-and meso-levels are defined and compared. Last we define a the *type of actors involved* in the development and promotion of innovations and the diverse rationales amongst them (e.g., research institutes, companies, governments, NGO's and intermediary organizations). The matching if these five dimensions is fundamental for the implementation of systematic innovation policies across diverse sectors.

Eight innovation policy instruments from several institutions where analyzed, regarding their support for three relevant Dutch policy papers. The results show lack of integration of policies, contradictions and fragmented deployment of instruments. In addition the analysis indicates that some barriers to the innovations promoted are hardly addressed while others are over dimensioned, thus leading to a non-optimal policy effort and waste of governmental funds. Despite that the method has been applied in the Dutch context the approach to better co-ordinate diverse policy instruments towards sustainable innovation can be applied in diverse countries and institutional settings.

2. A method for policies coordination assessment

In the method proposed coordination amongst policies is seen as a prerequisite to achieve some degree of integration in the tackling of the many and diverse challenges that sustainable innovation may imply.

2.1 Five types of environmental innovations

The first category to assess the degree of integration of policies to promote environmental innovations regards five types of innovation. Heterogeneity and variety are key features of technology and innovation.

There are basic facts that need to be taken into account in the design and implementation of innovation policy. For example, the development and successful implementation of the electric car demands a different policy from that needed for the promotion of sewage plants. There are as many technological innovations in our doorstep as there are environmental problems. This presents a problem when intending to design policies aiming to account for such a basic fact.

The question here is how do we account for heterogeneity in a sensible manner? What makes innovations different? In order to respond to these questions we propose to classify environmental innovations according to the degree of structural organisational change required and amount of technical change required that the innovation implies [DTO, 1996]. In the case of the structural change required there are technological innovations that have limited or no impact on organisational structures (i.e., end-of-pipe) while other like innovation on technological systems may well require changes on the organisational structures of networks of organisations (i.e., systemic innovations). For the amount of technical change this will vary from optimisation, to incremental, to radical innovation. We can expect that with increasing levels of technological change, costs will rise hand in hand with uncertainty and the risk of failure. While when the necessary change in organisational structures is more profound we can expect more parties to be involved in the innovation process. This will cause the 'process component' of the necessary policy to increase.

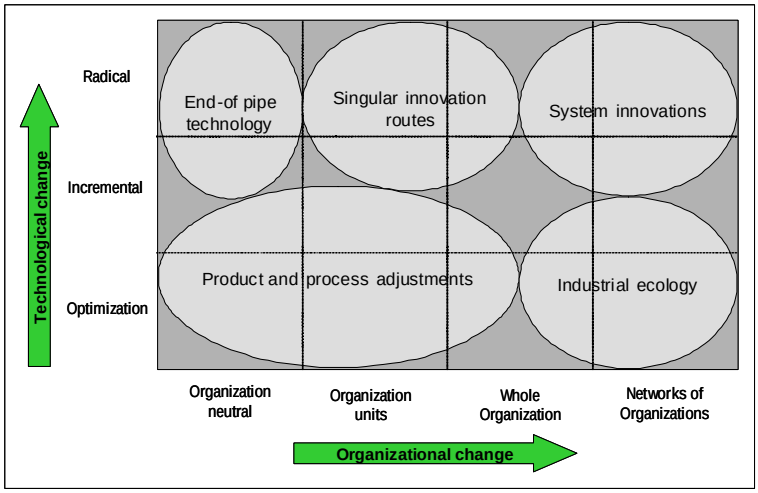

Figure 1 *Five types of innovations*

From the literature on the greening of industry, cleaner production and environmental innovations five types of environmental technology paradigms can be differentiated: End-of-pipe, adaptations of products and process, singular innovation routes, industrial ecology and systems innovation. These types of innovations are defined below:

End-of-pipe technology

In this category, technologies at the end of the chain, decontamination and clean-up technologies are found. They involve relatively complex technological change and additional costs, but come without the necessity for significant change in the business organisation.

Adaptations of products and processes

Adaptations of products and processes aim at increasing the quality or bringing down the costs. These adaptations ask for limited structural and technological changes.

Singular innovation routes

New processes and products are introduced, aimed at conquering new markets. This goes together with a certain degree of both technological and structural innovation.

Industrial ecology

The closing of certain materials and ecological cycles at the regional level, aiming at decreasing the burden on the environment and bringing down costs. Several parties are involved, but there is no need for complex technological change.

System innovations

A completely new arrangement of societal needs, combining change on the company, the meso or network level, and sometimes even on the macro or landscape level. This kind of change involves major and complex technological and structural changes.

The environmental innovations defined above are depicted and located in Figure 1 in a two dimensional space. The space is defined by the levels of structural changes in organisations and the degree of change that the innovations imply.

Form Figure 1 is obvious that there aren't clear cuts between traditional environmental technology and singular innovations and between the other innovation types. An example of this is a silver (salt) regeneration installation that aims at cleaning the process water coming from a chemical photo development process.

One might look at this technology as an end-of-pipe technology while at the same time it is part of a process recycling step. Furthermore, the value of end-of-pipe technology in comparison to singular, process-integrated technologies tends to be underestimated. Sometimes, the process-integrated technology is less attractive from a sustainability point of view, for instance because of higher energy consumption, higher costs, or because of other reasons. In general, it can be argued that the types of innovations above defined are interlinked. System innovations can, for instance, be regarded as the result of an orchestrated cluster of singular innovations. Adaptations can, to a certain degree, also be part of this whole process of change. The degree of overlap on the environmental innovations depends on the system's demarcation.

2.2 Innovations life cycle

The second category to assess the degree of integration of policies to promote environmental innovations concerns the life cycle of any innovation. In this respect, innovation policies aim to support the innovation route, policies that which will eventually lead to the implementation and use of an innovation. The innovation route has been traditionally regarded as a sequential phenomenon. But in reality, it is a process of 'creative destruction', with a strong interaction between the knowledge infrastructures, the business world, the government, and, last but not least, the market [Kline & Rosenberg, 1986]. The stages generally involve the generation of an invention, the development of the invention, industrial production, marketing and adoption (diffusion) of the final innovation (product, process or service). The stages are defined below:

- **Invention**
  The creation of new ideas and concepts. This involves visionary thought. An impediment to this could be a lack of cross-linking between relevant fields of interest.
- **Development**
  The transformation of ideas and concepts into actual innovations (pilot projects). This is the research phase and therefore it mainly involves researchers. Budgetary problems are the main source of impediments.
- **Production**
  The development of a commercial production process for large-scale production. This phase also involves a great deal of research.
- **Marketing**
  Knowledge transfer towards market parties. During this phase, intermediary organisations play a major role. This phase can be hampered by a lack of examples.
- **Adoption**
  The innovation has to be implemented. This requires user-level adjustment (innovation). Implementing

an innovation is a high-risk activity as a consequence of growing pains, surplus costs, and necessary adjustments within the organisation.

Based on the parties involved, the kind of activities carried out and the relevant impediments, a cyclic innovation model can be used [Broersma et al, 2001]. Figure 2 presents a schedule of the innovation chain.

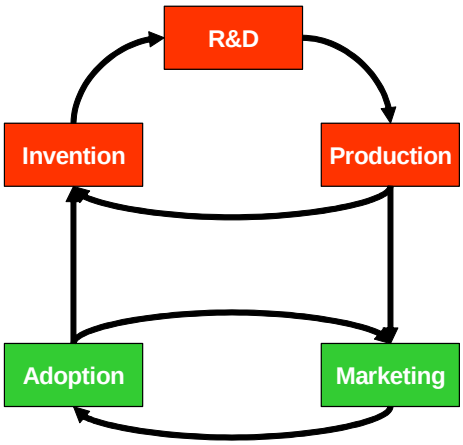

Figure 2 *Five activities in the innovation chain*

A supplementary sixth phase is **knowledge generation**. This activity is predominantly located at universities, and is a supplier for all activities. Fundamental knowledge is inspiring for the process of *invention*. During the phases of *development* and *production* new 'knowledge insights' deliver new possibilities to shape product or process. But also during *communication* knowledge can lead to new means of communication.

The conclusion to be drawn from this schematic overview of the innovation route is that an innovation route can be regarded as a chain. This chain is as strong as its weakest link. This means that as any given government policy strengthens one aspect of the chain (e.g., R&D) while leaving alone the rest we can expect that the effectiveness of the policy will be limited.

2.3 Generic barriers to innovation

The third category to assess the degree of integration of policies to promote environmental innovations focus on the generic barriers to environmental innovations. An innovation route can be regarded as the development of a new technology concept, followed by implementation and use. A new technology system overcomes a certain resistance from society and eventually replaces the old technological system. At first, resistance will be strong, but a successful innovation gradually becomes a better offer to society than the old system. In the case of an innovation that is in accordance (or aligned) with the market, here the market parties themselves are able to overcome the initial impediments. They seek profit and expect that eventually the new system will replace the old one. The initial impediments (investments, new organisation structures, etc.) can be overcome by the market party. In this situation the risk of failure is not too high.

Around some innovations, situations can arise in which an innovation route does not develop, or develops too slowly (from the government perspective). Government policy is necessary in order to realise much wished innovations with a societal importance. According to us, three fundamental situations can be distinguished that can impede an innovation (see Figure 3):

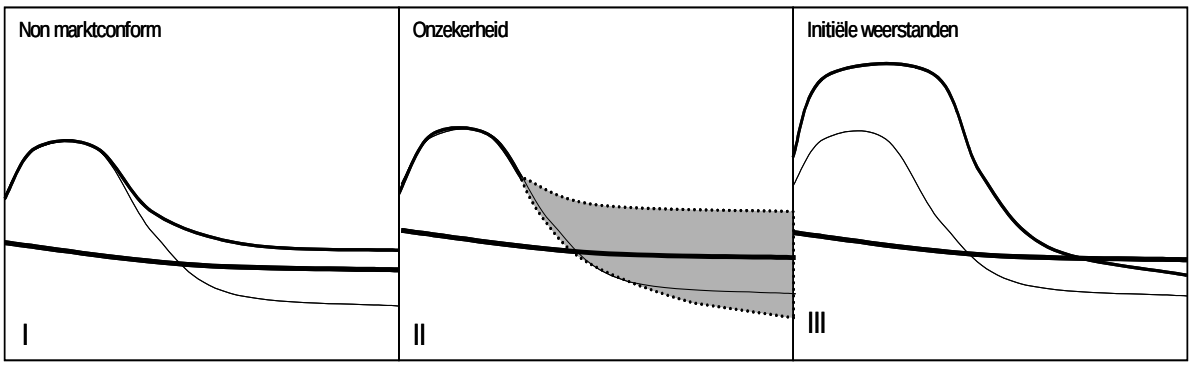

Figure 3 *Three different situations in which innovation is impeded or does not come into being.*

- **Figure 3.I shows an innovation that is not in line with market preferences**
  In this situation, the new situation meets more resistance than the old one for a long period of time. The new system is not accepted in the existing market order. The origin of this can be found in:
  - System imperfections within the government (laws and regulations, connection to fields of governance).
  - Higher corporate costs as compared to application of the old system (marginal costs).
  - The investor has no way to get at the profits that are made with the innovation.
  - Societal acceptance (cultural resistance, as with Genetically Modified Organisms).

- **Figure 3.II display an innovation that faces high uncertainty**
  If the development and implementation of a new technological system comes with high uncertainty, leading to risks exceeding the normal business risk, we call that a high risk of failure. The origin may be found in:
  - the fact that there is no standard. It remains unclear which additional technologies are necessary.
  - the fact that the long-term perspective is just too far away for companies, with cost recovery periods that are too extended.
  - the fact that market developments are unclear, both for the technology (which technology is feasible) and for the market (what technology will the user choose).

- **Figure 3.III depicts an innovation that confronts major initial resistance**
  In this situation, the new system will probably lead to a final situation in accordance with the market. Imperfections in the market, however, lead to high initial resistance that has to be overcome in order to pave the way for development and implementation by the market parties. The origin of this may be found in:
  - lock-in of the old system, including 'sunk costs' (technical, financial and human).
  - a limited availability of capital (financial and human)
  - the fact that co-operation agreements can only be made with difficulty, as a result of opposing interests and the absence of a common frame of mind.
  - The absence of an initial 'critical mass' for economic use (economy of scale, growing pains).
  - Hampering knowledge transfer and insufficient popularity in the market.

In principle, these barriers are relevant for every type of innovation. They cover each activity during the innovation route, but some will be more dominant during specific phases than others.

2.4 The policy target groups

The fourth category to assess the degree of integration of policies to promote environmental innovations main the actors involved on environmental innovations. Here the basic assumption for an environmental innovation policy is that the societal forces will have to perform the required change. An innovation route involves various parties, with different roles and different incentives. The following parties can be distinguished from the perspective of the policy maker.

- The first category is that of the ***knowledge institutions***. These organisations predominantly provide new knowledge and are closely linked to the government. They get their funding mainly from the education budget. Universities, large technology institutes and university-linked institutions are mainly driven by broad societal issues (direct and indirect government funding). An important factor is the sense of urgency of the researchers themselves.

- An important category of parties for the realisation of innovations is that of the ***corporate world*** (both for development and implementation). The industry is primarily focussed at continuity of their management. This means that both the demand side of society (consumers and companies as customers) and their own employees strongly influence their activities. But the government also

influences the direction by way of issuing permits and generally influencing market mechanisms. In short, their activities are defined by the expectancy of market opportunities, demands by consumer and government, the vision of employees, and demands by companies as customers.

- The ***intermediary organisations*** play an important facilitating role, but ask for financial support in return. They can help with knowledge transfer and other ways of bringing together demand and supply.

- The ***consumer*** is eventually the buyer and user of innovations. This might be interpreted in the direct sense (products) and in an indirect sense (underlying processes). This category is often directed by financial and economical motives. To a limited degree, sustainability aspects influence the buying behaviour of the general public.

2.5 Three layers, four dimensions

Three layers
The aim of the environmental innovation policy is realisation of innovations. In paragraph 2.2, the different types of innovations were presented. They are interconnected. With regard to the present environmental policy (NMP4), it has become clear that both singular and system innovations are necessary. This has consequences for the policy, as system innovations can be considered as a cluster of singular innovations. This appears to ask for a two layer policy. Apart from that, the analysis of the impediments has shown, that generic problems can occur, preventing environmental innovations in general (not in accordance with the market). The contours of a three layer policy come into sight:

- **Generic policy**
  This policy layer targets the generic support of the climate for innovation in the fields of the environment and sustainability.
- **Policy on system innovations**
  Central issue of this layer of policy is to bring parties together in order to initiate complex, multi-actor, and multi-level innovation routes. Long term focussing of effort is the main goal.
- **Policy on singular innovations**
  The aim of this policy is stimulation of innovations that lie within the reach of individual organisations and companies.

While making the choice of policy instruments it is important to address all three of the policy layers.

Four dimensions
Looking at the components for a systematic approach towards the environmental innovation policy, the conclusion is justified that the policy should support all weak links in the chain. If a weak link should remain, chances are that all efforts have been invested in vain. This asks for a balanced mix of policies. But how can this mix be defined?

From the description of the components it can be concluded that there are four dimensions of interest for defining an optimised policy mix:

- **Type of innovation**
- **Phase on the innovation route**
- **The impediments**
- **The target group**

During the execution of the policy mix it has to be observed that the policy instruments fits with the type of innovation, that all bottlenecks relevant for each link of the innovation chain are covered, and that the target groups playing a prominent role in innovation are supported.

3 Eight instruments reviewed

This section applies the framework presented above to assess the gaps and (mis-) match of a set of instruments used in the Netherlands to promote environmental innovations. This exercise builds on a detailed study and description of eight policy instruments promoting environmental innovations [see Weterings et al, 2002]. The set of analysed instruments address ten broad policy domains. The issues are: sustainable agriculture, sustainable industrial production, impact households, sustainable energy production, sustainable transport, soil sanitation, reduction of production costs, new markets for environmental innovations, strengthening the knowledge base and usage of existing knowledge. The set of instruments addressing these policy domains are listed in the table below.

Table 2 *Eight environmental innovation instruments analysed*

Acronym	Policy instrument
ProMT	Program Environment and Technology
EET	Program Economy, Ecology en Technology
IOP	Innovation Oriented Research Programma
SP	Cleaner production
Vamil	Free depreciation of environmental investments
Bie	Bureau for Industrial Property
Infomil	Information Centre for Environmental permits
Conv.	Convenants

3.1 Types of innovation

The analysis of the policy issues mentioned above shows a clear demand for system innovations and singular innovation routes. This originates from the conclusion reached in the Fourth Dutch Environmental Program (NMP4): in order to solve persistent environmental problems, dramatic changes of production and consumption are inevitable. The memorandum 'Room for industrial innovation' also values highly the innovation routes involving clusters of parties, and finding completely new markets. Despite an implicit demand this memorandum does not mention the need for system innovations as such instead it focuses on entirely new knowledge and technology. Since the realisation of system innovations asks for singular innovation routes as well, it is obvious that these singular routes cannot be ignored.

From the analysis of the focus of the policy instruments above it can be said that there is a limited demand for policy instruments supporting end-of-pipe technology. This demand mostly concerns soil remediation. In the field of industrial ecology the policy issues are limited, yet significant. Most questions are brought forward by NMP4 and the LAP. Figure 5 below shows the eight policy instruments placed in the two dimensional space proposed in Section 1. The policy instruments are organised according to the level of structural changes that they demand from organisations and the intensity of the change. The figure makes simple the depiction of the type of innovations that the instruments are intended to promote and the gaps in policy.

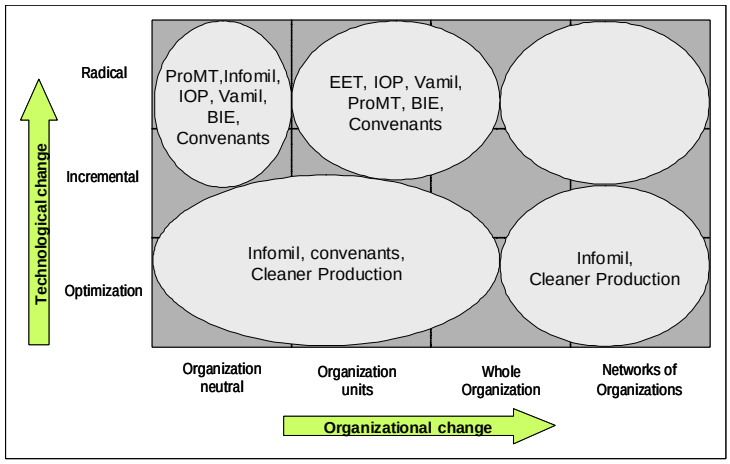

Figure 5 *Connection of instruments to types of innovation*

The above figure shows that system innovations hardly attract attention. At first sight, the innovations of the ‘end-of-pipe’-, ‘adjustments to product or process’-, and ‘singular innovations’-type appear to be fairly well covered. ‘Industrial ecology’ receives a little less attention. But a closer analysis remains necessary in order to pull the object into focus.

3.2 Instruments and domains

The policy documents reviewed all work from a different angle. The existing policy instruments focuses on these specific angles.

Table 3 Linking instruments and policy domains.

	IOP	EET	BLE	ROM	Veni	Infomil	Pro
		+					
[redacted]	+++	+++					
[redacted]	++	+++					
[redacted]		+++					
[redacted]							
				+	+	+	+
	+++	+++					
[redacted]	+++	+++					
[redacted]	++	++					

+: Limited relevance; ++: General relevance; +++: Specific attention

Especially sustainable industrial production receives specific attention. The use of the knowledge base is supported in a more generic way. It is striking that the eight analysed instruments have little attention for households, agriculture, soil contamination, and mobility.

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3.3 Coverage of innovation types

Adjustments to processes/products

Individual organisations are primarily responsible for adjustments to products or processes. Cost reduction and quality improvement are the incentives to start innovating. Apart from this, environmental measures can be demanded through the grant of permits and licences– or by denying them. Not surprisingly, neither policy memoranda nor the analysed instruments pay much attention to this type of innovation. *Infomil* provides the departments that grant permits with information on these measures

End-of-pipe technology

End-of-pipe technology will, in principle, raise costs. Economic advantage mainly originates from sales of innovations. It is crucial to state that the adoption of this kind of technology will rarely, if ever, demand major adjustments to the corporate structure (structural problems of organisation change). This kind of innovation is often demanded by either pricing, or else the policy on licences and permits (think of taxation).

Table 4 *Relevance of the policy instruments for the innovation chain and impediments regarding* ***end-of-pipe technology***

Barriers	Basic knowledge	Invention	R&D	Production	Marketing	Adoption
System imperfections					Conv.	Conv.
Higher marginal costs					Conv.	Conv.
Split incentive	Bie		Bie		Conv.,Bie	Conv.,Bie
Societal acceptance						
Uncertain technological developments					Vamil	Vamil
Long term perspective	EET		EET			
Uncertain societal developments						
Lock in					Conv.	Conv.
Financing	IOP,EET		IOP,EET, ProMT	ProMT	ProMT	ProMT
Co-operation	IOP,EET		IOP,EET		SP	
Initial critical mass						Vamil
Knowledge transfer	IOP,Bie		IOP,Bie,ProMT	ProMT	Bie,ProMT, Conv,SP,Vamil	ProMT,Conv, SP,Vamil

The various policy documents still award end-of-pipe technology an important role. This goes especially for the domains of soil contamination and negative influence on the environment by agriculture and industry. Regarding the innovation route, bottlenecks are felt during all activities. Among the impediments, system imperfections, high marginal costs, split incentive, uncertainty of technological breakthroughs, capital, and knowledge transfer are predominant.

To what extent do the eight policy instruments support this type of technology?

Looking at the above table, it is striking that the connection is only very limited. Especially the incubator for new ideas and concepts is not supported. Also, the track from prototype to industrial production is a bottleneck[1]. Stimulation of the acceptance in society is not covered at all. One may wonder whether this is also a problem with regard to end-of-pipe technology, although the Brent Spar issue indicates that this should not be put aside that easily. The uncertain market is a considerable problem indeed. Often, with this kind of innovation the ‘unreliable government´ is mentioned, clearly impeding the potential market. In general, the conclusion that the support is not impressive seems justified. Because of the complexity of the issue, support by several instruments would be expected.

Singular innovation routes
This type of innovation includes innovations among individual parties, requiring no or hardly any coordination with other parties. This does not mean that other parties may not be involved, but these play the role of subcontractors of the leading party. The policy documents notice a considerable role for this type of innovations. This is of course the place for innovations leading to less stress on the environment, and to novel markets at the same time.

With regard to singular innovations, support of the innovation route as a whole is wished. A weak link among any of the activities will lead to diminished efficiency for any instrument that was used.

Regarding the impediments, some are of minor importance, like co-operation, acceptance in society and the long-term perspective. The other aspects need support.

[1] The SKB actually offers such support, but was not included in the analysis.

Table 5 *Relevance of the policy instruments regarding the innovation chain and impediments, as to* ***singular innovation routes.***

	Basic knowledge	**Invention**	**R&D**	**Production**	**Marketing**	**Adoption**
System imperfections					Conv.	Conv.
Higher marginal costs					Conv.	Conv.
Split incentive	Bie		Bie		Conv.,Bie	Conv.,Bie
Societal acceptance						
Uncertain technological developments					Vamil	Vamil
Long term perspective	EET		EET			
Uncertain societal developments						
Lock in					Conv.	Conv.
Financing	IOP,EET		IOP,EET,ProMT	ProMT	ProMT	ProMT
Co-operation	IOP,EET		IOP,EET		SP	
Initial critical mass						Vamil
Knowledge transfer	IOP,Bie		IOP,Bie,ProMT	ProMT	Bie,ProMT, Conv,SP,Vamil	ProMT,Conv, SP,Vamil

It is striking that the development of new concepts (invention) does not get much attention, if any. The instruments mainly support the elaboration of new concepts. Also, the up scaling of a prototype, or pilot project, to the commercial level (production), is only awarded limited attention. Another conclusion is that in the policy instruments *innovation* and *diffusion* seem to be strictly separated.

The table above shows that necessary capital, co-operation and knowledge transfer are firmly supported. The other seven types of impediments are not, or hardly, supported, with a downright gap at *uncertain market* and *acceptance in society*. Another look at the instruments even tells us that the other bottlenecks are often addressed only marginally. The conclusion is, after all, that the set of instruments mainly focuses on financial support for innovation, and on knowledge transfer.

Industrial ecology

Industrial ecology is all about co-operation of organisations in order to close cycles at the regional level. Most of the time industrial ecology involves major changes in organisations that could be supported by technology. The policy documents pay limited but significant attention to this type of innovation. This type of innovation mainly asks for a process-oriented approach. The table below shows how the various policy instruments support the different innovation activities for industrial ecology.

Table 6 *Relevance of the policy instruments for the innovation chain and impediments regarding* ***industrial ecology.***

	Basic knowledge	**Invention**	**R&D**	**Production**	**Marketing**	**Adoption**
System imperfections					Conv.	Conv.
Higher marginal costs					Conv.	Conv.
Split incentive					Conv.	Conv.
Societal acceptance						
Uncertain technological developments						
Long term perspective	EET		EET			
Uncertain societal developments						
Lock in					Conv.	Conv.
Financing	EET		EET			
Co-operation	EET		EET			
Initial critical mass						
Knowledge transfer					Conv	Conv,

The conclusion here is that the analysed policy instruments pay hardly any attention to industrial ecology. Binding agreements on co-operation within regions can be made, but even here the attention is limited. *Infomil* facilitates the implementation process through information services, but this, again, only to a limited degree.

Industrial ecology has to cope with bottlenecks, because co-operation between organisations is vital. It demands new investments and the existing (technological) infrastructure will cause a lock-in effect. Also, the investor will most likely see little revenue for his investments (split incentive). The existing laws and regulations only fit this type of innovation to a limited degree. From the above table it can be concluded that the impediments felt with industrial ecology are covered by the analysed policy instruments. It should be remarked that there are in fact some other policy instruments aimed specifically at this type of innovation.

The table above shows that the coverage of the instruments towards the target groups is limited. A closer look at the instruments learns that especially a pricing tool is lacking.

System innovations
The development and realisation of system innovations asks for additional policy. It involves large scale, long term development routes, in which various parties should bundle their efforts. The policy is mainly aimed at this process of getting parties together. Especially the NMP4 calls for this kind of innovations, but also the memorandum ‘Room for industrial innovation’.

The analysis of the instruments shows that none of the instrument analysed pays explicit attention to this kind of innovations. The conclusions from this must therefore be that policy development on this issue is highly necessary[2].

Target groups

[2] The NIDO (Netherlands Institute for Sustainability Research) was founded specifically for supporting the realization of system innovations. This ‘tool’ is not included in the analysis. But it has to be remarked that the contribution is not yet clear, and that it cannot be concluded beforehand that the NIDO fills the gap completely.

Not all policy instruments provide a perfect match with specific target groups. This has to do with the role target groups play in the innovation route. It is not a surprise that a tool aimed at the development of actual research and development, aims at the business world and knowledge institutions. But other target groups also have their part to play in the innovation route. This involves, for instance, acceptance in society (aspects of structure). The type of innovation influences the necessity of involvement of potential target groups in the innovation route. No explanation is needed for the fact that commitment of organisations in society for system innovations is more intensive than for end-of-pipe technology, or product and process adjustments. The table below presents an overview of coverage of various instruments for the different target groups, with the types of innovation in the background.

Table 7 *Relevance of the policy instruments and types of innovation for target groups.*

	Systeminnovations	Industrial ecology	Singular innovations	End-off-pipe technology	Proces/product adjustments
RTO's		EET	EET,IOP,ProMT Bie	IOP,Bie	
Business: Multinationals		EET,IOP	EET,IOP,Bie	IOP,Bie, Conv.	Conv.
Business: SME's			ProMT,Bie, SP, Conv. Infomil	Bie, Conv. Infomil	Conv. Infomil
Intermediairy organisations			ProMT,SP		
NGO's					
Consumers					
Governments			Infomil	Infomil	Infomil

A glance at this overview inevitably leads to the conclusion that especially societal organisations and the consumer do not get attention in the policy instruments.[3] The instruments provide interaction with society in a limited way at best. Intermediary organisations are also left out of the equation almost completely. The absence of consumer involvement, and that of societal organisations, when it comes to system innovations and industrial ecology, is rather a problem. The issue of acceptation in society is at stake here. For other types of innovation this is a smaller problem, although more attention would also be appropriate.

The limited attention for intermediary organisations in the policy instruments is cause for concern. This target group could contribute considerably to the knowledge transfer and co-operation. Far better use could be made of this potential. Furthermore, the lack of government commitment regarding instruments for the support of system innovations and industrial ecology can be regarded as undesirable. It involves innovations that are mainly fruitful at the level of society at large. Government commitment could contribute to decrease this 'split incentive'.

4 Towards an environmental innovations policy

[3] The government information in the 'postbox 51' ads has a certain degree of attention to the target group of consumers. This aspect was not included in the analysis.

4.1 Recommendations according to the evolutionary theory

Before systematically filling in the framework for the environmental innovation policy, the evolutionary theory can be used to formulate the preconditions for this policy. For the environmental innovations policy, the following conclusions can be drawn [Butter, 2002]:

- *Develop a policy from the perspective of a demand's function.* The societal demands play a central role. The market must be given the proper room to come up with the right solutions.
- *Leave room for variation, but select in time.* Stimulating the market to develop different options is important. But from the perspective of capital disinvestment, selection is just as important. The government has a process role in this respect.
- *Pay attention to both horizontal and vertical networks.* Innovation increasingly has the characteristics of a network. Both parties in the value chain and parties linked to them crosswise deserve attention. An integrated approach is necessary.
- *Develop a multi-sector perspective.* 'Bandwagon effects' play an important part in the commercial success of an innovation route. Technologies therefore should not be developed for only one application, but with a broader perspective in mind.
- *Watch out for structure effects.* Innovation must be imbedded in society. An effective policy pays attention to the way in which innovations must adapt to their surroundings.
- *Make room for experiments in policy.* Innovation has become very complex. Generic instruments do not suffice. New instruments are necessary, and this calls for experimenting by the government.

These issues can be regarded as a starting point for an environmental innovation policy.

4.2 Three layers of policy

Solving the persistent environmental problems as mentioned in the Dutch NMP4 asks for a mix of new singular innovation routes and system innovations. Even end-of-pipe technology and industrial ecology are types of innovation that should be supported in order to facilitate sustainable development. The new type of innovations first asks for a generic policy in order to provide a climate for innovation in which environmental innovations are stimulated. A generic policy in itself is necessary but inefficient and ineffective:

- Inefficient, because the environmental innovations policy is confronted with specific problems (see impediments). An overall generic policy will lead to innovations that are irrelevant from the societal point of view.
- Ineffective, because the innovation route is a chain of weak links, which should all be strengthened. This asks for customisation, as a satisfactory adaptation to current issues.

Custom-made solutions are necessary in order to diminish the effects of specific impediments. The attention to impediments might change during the course of time. The various types of innovation and environmental innovations may be system innovations, or even just a part of system innovations.

4.3 Fit of the policy instruments regarding the policy domains

The analysed policy instruments are predominantly aimed at the realisation of sustainable industrial production and sustainable energy. Households, soil contamination, and mobility receive less attention. Despite this it can be argued that the instruments show a reasonable spread regarding the various domains

(with an exception for a tool like IOP). The domain does not seem to be a dimension demanding a large amount of specification.[4]

As to the target groups, another picture appears. Generally speaking, the analysed policy instruments pay little attention to societal organisations consumers and government parties. But these play a vital role when it comes to acceptance of innovations by society. This is especially a problem for system innovation, but it may also cause considerable problems for singular innovations and industrial ecology. Furthermore, intermediary organisations hardly get any attention, although this is normally regarded an asset of our economic system. Their role in knowledge transfer can contribute greatly to the diffusion of innovations and mutual exchange of assets between various sectors.

The type of innovation is mainly aimed at singular innovation routes. Although there seems to be a certain coverage for the other types of innovation (with the exception of system innovations), a closer look reveals the inadequacy in this respect. The conclusion is therefore, that the analysed policy instruments are poorly connected to the policy issues at stake in the NMP4. In a certain way this also goes for the other two memoranda that were studied. It appears that the analysed policy instruments have a closer fit to older memoranda like the NMP3 and the memorandum Environment and Economy.

When looking at the innovation route, the conclusion must be that the instruments allow a gap when it comes to *invention.* The generation of new ideas is important in order to have a promising supply of new innovations. (think of: 'let a thousand flowers blossom'). Furthermore, the support for necessary innovation in the phase of upscaling of new concepts to a broader field of application can be rated as virtually non-existent. Only ProMT pays attention to this aspect. Nevertheless, this is an important link in the innovation chain. The problem cannot be put aside with the remark that this is the domain of the company itself. The fact that many possible innovations are gathering dust on the shelf is proof of this bottleneck.

The impediments add further graduation to this picture. It appears that the policy instruments are mainly aimed at problems in the financial and economical domains, and that of knowledge transfer. Other crucial impediments like acceptance in society, the issue of an uncertain future development, and the lack of initial critical mass are virtually not addressed, let alone solved. When looking at the analysed policy instruments, some instruments appear to be very much alike:

- IOP and EET seem to have a lot of overlap at the level of target groups, innovation activities, and impediments. The EET however lacks attention to knowledge transfer and the IOP lacks attention to more large-scale innovations. On the side of direction and content (domain and type of innovation) there is also a certain overlap, although it should be remarked that EET has a somewhat broader field of application, and that the IOP also addresses end-of-pipe technology.
- When it comes to knowledge transfer, a merger of various instruments seems to be possible. Bie, Infomil, Schoner Produceren, Vamil, ProMT, and mutual agreements between economical sectors and the government all have, to a certain degree, equal goals and target groups. Integration of the knowledge transfer elements must be possible in our opinion.
- There is a clear-cut rupture between innovation and diffusion of innovation. This is a point of concern. An extension of the policy instruments, or else a large degree of co-ordination is necessary in order to come to an effective and efficient approach.

An important point is that the analysis starts with the assumption that the instruments are effective. This is in fact questionable. Measuring the effectiveness of instruments is very hard indeed. Because of this measuring problem, a presumption on the non-effectiveness of the set of policy instruments would not be

4 Before conclusions are drawn on the policy instruments for the Dutch context, it must be remarked that the eight selected policy instruments represent a limited selection. Examples like the SKB and the Nido point out, that the conclusions must be regarded as limited.

appropriate. Furthermore this would only lead to a larger gap between the policy instruments and policy issues in the diverse domains.

4.4 Final remarks

The study shows a picture of a fragmented deployment of policy instruments. A systematic approach that encompasses diverse policy domains and issues is lacking. This leads to a waste of government funds. Some fields of interest are not covered at all, while others are covered by a range of instruments.

The following conclusions and recommendations are given:

- When looking at the three policy layers, it appears that mainly the layer of singular innovations is covered.

- In the analysed policy instruments gaps were identified in reference to:
  - *Target groups*: There is only limited attention for intermediary and societal organisations, the consumer, government parties and to a limited degree small and medium sized businesses.
  - *Innovation activities*: The eight analysed instruments hardly support the invention and production phases
  - *Barriers*: System imperfections, higher marginal costs, split incentive, long term perspective, acceptation in society, uncertain future developments, and initial critical mass are hardly addressed.

- For some instruments a combination could be considered:
  - EET and IOP, with necessary adjustments in the field of large scale experiments and broadening of domains.
  - Knowledge transfer activities of: Infomil, Vamil, Schoner Produceren (cleaner production), ProMT en Bie.

- Hardly any of the analysed instruments supports the meso aspects of system innovations. There are more than sufficient leads for the combined singular innovations.
- The policy instruments for industrial ecology are also insufficiently equipped. The instruments at hand should be used (extension might be an option).
- For end-of-pipe technology the analysed policy instruments is insufficient. This, combined with the conclusion that this type of innovation still remains vital for solving persistent environmental problems, leads to the conclusion that additional measures are desired.
- The analysed policy instruments hardly pay any attention to the embedding of technology in society. This reduces the efficiency and effectively of government funds.

In short, the analysed instruments appear to cover the political demand inefficiently. Further narrowing down of the policy instruments is necessary. The generic policy instruments should be made sustainable. Furthermore, custom-made efforts for addressing specific sustainability problems should be further elaborated and focussed.

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